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Jong-Sun Lee, Andrew Mathews, Sukhi Shergill, Daniel Ka Yiu Chan, Nadia Majeed, Jenny Yiend

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How Can We Enhance Cognitive Bias Modification techniques? The Effects of Prospective Cognition

Jong-Sun Lee[1*], Andrew Mathews[2], Sukhi Shergill[1], Daniel Ka Yiu Chan[1], Nadia Majeed[1] & Jenny Yiend[1**]

[1]Institute of Psychiatry, King's College London, United Kingdom

[2]Department of Psychology, University of California, Davis, U.S.A.

Corresponding Author:

*Jong-Sun Lee

Institute of Psychiatry, King's College London

PO 63, De Crespigny Park, London SE5 8AF, UK

e-mail: sunny597@gmail.com

**Jenny Yiend

Institute of Psychiatry, King's College London

PO 63, De Crespigny Park, London SE5 8AF, UK

e-mail: jenny.yiend@kcl.ac.uk

1. JongSun Lee is now at graduate school of medical science and engineering, KAIST, Republic of Korea

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Abstract

Background and objectives: Cognitive bias modification for interpretation, a computerized program which manipulates biased interpretations, has shown therapeutic promise, including evidence that negatively biased interpretations can be reduced, leading to corresponding improvements in symptoms. Cognitive bias modification for cognitive errors (CBM-errors) is a second generation CBM-I procedure which manipulates seven types of cognitive error and is especially relevant to depressive cognition. The aim of this study was to investigate whether the effects of the CBM-errors manipulation would be enhanced by adding a component facilitating prospective cognition to help embed and extend newly acquired interpretations.

Methods: A sample of 80 volunteers completed a single session experiment. With a pretraining-posttraining design, we compared the effects of enhanced CBM-errors (targeting cognitive errors plus prospective cognition) with standard CBM-errors (targeting cognitive errors without prospective cognition), on interpretations of new material and mood.

Results: Significant differences between enhanced and standard CBM-errors revealed that enhanced positive training was more effective at decreasing negative interpretations compared to the standard procedure.

Limitations: Extending the current investigation to a sample dysphoria or depression is needed for an appropriate next step.

Conclusion: The findings serve as 'a proof of principle' for the potential of prospective cognition to enhance the effects of CBM-errors and other similar CBM procedures. Further work to enhance the effectiveness of CBM procedures is needed.

Keywords: Cognitive Bias Modification, Prospective Imagery, Depression, Cognitive errors

1. Introduction

Changing cognitive bias is considered a powerful therapeutic mechanism for mood disorders. Cognitive Bias Modification that targets interpretation biases (CBM-I) is a computerised experimental method for modifying the interpretation of emotionally ambiguous information, and has shown promising therapeutic effects in subclinical and clinical disorders (Blackwell & Holmes, 2010; Lang, Blackwell, Harmer, Davison, & Holmes, 2012; Lang, Moulds, & Holmes, 2009; Lester, Mathews, Davison, Burgess, & Yiend, 2011; Yiend, Lee, et al., 2014; Yiend, Parnes, Shepherd, Roche, & Cooper, 2014). The core concept of CBM-I is to train people to interpret emotionally ambiguous information in a consistent direction, and CBM-I usually aims to shift spontaneously negative interpretations towards more benign or positive alternatives (Mathews & Mackintosh, 2000). The additional evidence that CBM-I can elicit mood, symptom and stress response changes has piqued interest in the development of CBM-I as a potential therapeutic tool.

Original versions of CBM-I were devised by Mathews and colleagues (Grey & Mathews, 2000; Mathews & Mackintosh, 2000). For example, Grey and Mathews (2000) trained unselected participants to interpret an ambiguous homograph (e.g., stroke, batter) in either a threatening or a positive way, and found that practice in disambiguating these words resulted in similar interpretations being made when responding to previously unseen words. Similar results were found in a study using more naturalistic material in the form of short emotionally ambiguous text passages related to social anxiety (Mathews & Mackintosh, 2000). In this and subsequent studies using this method, researchers have found training-congruent interpretations are applied to new ambiguous materials, as well as effects on state anxiety, response to stress (eg. Wilson et al., 2006) and symptom reduction (Amir & Taylor, 2012).

Cognitive Bias Modification targeting cognitive errors (CBM-errors), was developed from the previously described text method. CBM –errors differs from previous versions of CBM targeting interpretation, in two main ways. First, the approach differs conceptually in that it broadens the content and cognitive processes targeted by training to go beyond interpretation of emotional ambiguity which are used by earlier versions of CBM for interpretation (CBM-I). This is because CBM-errors was specifically designed to manipulate the cognitive error categories originally identified by Beck, known to be prevalent in depression, and targeted during cognitive therapy (Lester, Mathews, Davison, Burgess, & Yiend, 2011). Second, the method seeks to improve the face validity of CBM content to reflect the full range and type of cognitive errors typically targeted in therapy. Thus, items were not experimenter generated (as in previous CBM-I methods), but instead, were developed from specific exemplars generated in the clinic by clinicians practising CBT and their patients (see Lester et al for full details). Thus CBM-errors includes content which targets the 7 categories of cognitive errors identified by Beck and colleagues (Beck, Rush, Shaw, & Emory, 1979); selective abstraction, minimization, magnification, black and white thinking, personalization, overgeneralization and arbitrary inference (please see Yiend et al., 2014 for examples of modification items). A recent meta-analysis of CBM studies, however, indicated that the effect sizes of CBM are smaller than previously reported (Hallion & Ruscio, 2011). In a subsequent study using CBM-errors in clinically depressed groups Yiend et al., (2014) found that a single session of CBM-error training increased positive interpretations but there was no significant change in mood or emotional reactivity to a stressor. As such, one of the key questions in CBM research generally, and for CBM-errors in particular, is what factors could enhance its efficacy? Investigating factors that enhance CBM effects could have significant therapeutic implications and is being called for throughout the field (Fox, Mackintosh, & Holmes, 2014).

We chose to focus on depression in the current study because CBM studies in depression are lacking although there is convincing evidence of a negative interpretive bias in depression (Lawson, MacLeod, & Hammond, 2002; Wisco & Nolen-Hoeksema, 2010). In addition the long term outcome of depression treated in primary care is worse than previously thought (Yiend et al., 2009) suggesting that developing new, low cost, widely accessible and effective interventions for depression is an increasing priority for services.

Several previous studies have already attempted to examine factors which might contribute to the efficacy of the CBM procedure. For example, the transfer effect of CBM training was larger in conditions requiring active generation and selection of emotional meanings, compared to passive exposure during CBM-I training (Hoppitt, Mathews, Yiend, & Mackintosh, 2010). Others have demonstrated that using imagery rather than semantic-verbal processing during CBM-I training is more effective in producing emotional change (Holmes, Lang, & Shah, 2009). However, none of these studies has examined the role of prospective (ie directed towards the future rather than the present) cognition in the effects of CBM-I.

Positive prospective cognition includes a tendency to expect favourable and hopeful life outcomes, and this is characteristic of healthy people who show optimistic biases about the future (Weinstein & Klein, 1996). In contrast, depressed and dysphoric people show a lack of positive expectations about the future (MacLeod & Salaminiou, 2001), and this is associated with suicidal ideations (Holmes, Crane, Fennell, & Williams, 2007; Williams et al., 1996). MacLeod and Byrne (1996) examined the number of positive and negative future events generated by people with anxiety only, anxiety and depression and healthy controls. Only those with depression, as well as anxiety, showed reduced anticipation of future positive experiences, whereas as both groups showed greater expectation of future negative experiences compared to controls. Similarly, MacLeod, Tata, Kentish, and Jacobsen (1997)

found that a lack of positive future cognitions, but not an excess of negative future cognitions was observed in depressed patients. Miranda and colleagues (2008; 2007) provided supporting evidence that a lack of positive future expectations was associated with depression but not generalized anxiety disorder. Holmes, Lang, Moulds, and Steel (2008) also found that a highly dysphoric group appeared to show less vivid positive prospective imagery than a low dysphoria group. In line with previous evidence regarding the relationship between prospective cognition and emotional well-being, research proposes that cognition with a future time perspective might influence cognitive bias information processing (see Demeyer & De Raedt, 2014 for a review). That is, future time perspective cognitions, related to specific goals and motivational preferences lead to a preference toward positive information and away from negative information (Carstensen & Mikels, 2005). Demeyer and De Raedt (2014) found limited evidence that a more expansive future time perspective was related to avoidance of negative information. Similarly, the Reconstructive Memory Model (RMM) and Valuation Model (VM) explain that repetitive practice of positive future-oriented scenarios (RMM) might promote attribution of lower risk estimates and allocation of processing resources to positive-oriented stimuli, which increases expectations for occurrence of the events one practice (VM) (Miloyan, Pachana, & Suddendorf, 2014). Based on previous findings, it seems that prospective cognition/imagery might play a key role in emotional well-being and information processing.

The research reviewed above suggests that a deficit in positive prospective cognition might be specifically associated with depression and cognitive bias. When we think about the future, we mentally project ourselves forward to events using imagery (Suddendorf & Corballis, 2007). This suggests that adapting CBM techniques to include the induction of positive prospective cognitions with imagery could be one way of improving the efficacy of CBM for depression. In the present study we set out to investigate this by comparing an

adapted version of CBM-errors, designed to promote prospective cognitions using imagery, with the previously reported standard CBM-errors procedure, that focuses on the modification of 'present moment' cognitive errors alone. Any differential effect between standard CBM-errors and enhance CBM-errors would therefore be attributable to the added component of generating prospective cognition. Before applying prospective cognition component to clinically depressed population, as a first step, we included a non-clinical population. Any beneficial findings regarding prospective cognition may serve as a proof of principle evidence for future clinical adaptation of CBM paradigm using prospective cognition, especially for depressed population. Our design contrasted positive and negative training directions in a non clinical sample, therefore including four training groups in total: standard positive (SP), standard negative (SN), enhanced positive (EP), and enhanced negative (EN). Based on previous findings on the role of prospective cognition on mood or cognitive bias, hypothesis testing examined whether the effects of enhanced versus standard training differed, when analysing positive training and negative training separately. We predicted that enhanced, compared to standard, trained groups would show greater changes of state mood (happy, sad) and interpretive bias (positive, negative) over time (pretraining vs. postraining) in a direction consistent with either the positive or negative training condition. Specific hypotheses were as follows:

Hypothesis 1, mood measures: There would be a significantly larger increase in happiness and decrease in sadness from pre-training to post-training in the EP group compared to the SP group (and vice versa for the EN compared to SN groups).

Hypothesis 2, bias measures: participants in the EP group would show an increase over time (baseline to test) in positive bias and decrease in negative bias, as measured by the Similarity Rating Test (SRT). Conversely, participants in the EN group would report higher

negative bias and lower positive bias on the SRT than those in the SN group at test compared to baseline

2. Methods

2.1 Participants

Participants were recruited at King's College London via poster and circular emails. Participants were informed that the aim of the present study was to investigate how future directed cognition was related to depressive relevant thought and mood. Inclusion criteria were English fluency and no history of psychiatric disorders, psychotherapy treatment or psychiatric medication and score within the range of minimum 0 and maximum 13 on the BDI-II. Two participants were excluded after data recording, and replaced with new recruits, for the following reasons: meeting exclusion criteria at the time of testing ([1]>14 on the BDI-II); failure to complete the correct experimental protocol as designed. [2]The final dataset analysed comprised 80 participants, 31 males plus 49 females (*M* age = 25, *SD* = 7.89). This research was approved by King's College London Ethical Review Board (PNM/09/10-59).

2.2 Training material.

Fifty ambiguous text passages were taken from the CBM-errors training used by Lester et al. (2011). Passages were presented in 7 blocks, with the presentation of each item within the block being randomized. Each block targeted one of the 7 categories of cognitive errors typical in depression: selective abstraction, minimization, magnification, black and

1 Participants who scored 14 or above were excluded due to ethical reasons; negative CBM training is not advisable in people with high levels of depression.

2 The current experiment conducted power calculations using G*Power 3 (Faul, Erdfelder, Lang, & Buchner, 2007) to detect group differences in the Similarity Rating Task (SRT; main outcome measure). When using data from(Lester et al., 2011), a minimum sample size of fourteen per group would be required to detect a significant difference with an effect size of d = 1.14 on the SRT between groups with 80% power (alpha level 0.05, 2-tailed test). The indicated sample size was thus inflated to maximise the chance of detecting the deployment of induced bias effects between positive training conditions.

white thinking, personalization, overgeneralization and arbitrary inference. Six neutral practice trials were run in order to ensure that participants understood the procedure before beginning the main trials.

Standard conditions (SP & SN). Participants were asked to read the passages presented on the computer screen and do their best to think of themselves in the situations described. The passages were emotionally ambiguous but resolved either positively (without errors; SP) or negatively (with errors; SN). The participants were then asked to answer a comprehension question (YES/NO answer), followed by 8 seconds of continuing to think about the content of the passages ("concentrate on the words and meaning of the story now").

Enhanced conditions (EP & EN). Participants in the enhanced condition were additionally asked to imagine a future event related to the passage during the 8 seconds after the comprehension question. Participants were given a reminder ("Something in the future, specifically positive (for the EP group), or specifically negative (for the EN group), and involving yourself"). An example of the enhanced CBM-errors training is depicted in Figure 1.

INSERT FIGURE 1 HERE

Duration of each training program was matched across the four conditions.

2.3 Measures

The Beck Depression Inventory II(BDI-II: Beck, Steer, Brown, 1996) was used to check depressive symptoms at the screening stage.

Positive and Negative Affect Scale (PANAS; Watson, Clark, & Tellegen, 1988): both trait measures of positive and negative affect were included to check that trait mood was comparable across the groups.

Life Orientation Test - Revised (LOT-R; Scheier, Carver, & Bridges, 1994): LOT-R was measured at baseline to check the levels of trait optimism across groups. This was intended to ensure that any differences in prospective imagery after enhanced training were not attributable to trait optimism. This measure consists of 10 items (e.g., overall, I expect more good things to happen to me than bad) using a 4-point scale (1: strongly agree, 4: strongly disagree).

Visual Analogue Scales (VAS) were used to assess two aspects of mood ("how happy/sad do you feel right now") using two 10 cm continuous lines marked "not at all" at one end and "extremely" at the other, which participants marked to indicate their current state of happiness or sadness respectively. A higher score therefore indicates a greater level of the corresponding mood. The VAS showed a good reliability and validity to assess state mood (Abend, Dan, Maoz, Raz, & Bar-Haim, 2014; Cella & Perry, 1986).

The Similarity Rating Test (SRT; Mathews & Mackintosh, 2000) measured interpretative bias using 14 items corresponding to two each of the seven categories of cognitive errors (Beck et al., 1979). Two parallel versions of the SRT were used in counterbalanced order before and after the training program. The task is composed of two parts: the encoding of ambiguous descriptions followed by the recognition rating of possible interpretations. In the encoding part, 14 ambiguous passages commonly experienced in daily life, that could be interpreted in a negative, positive or neutral way were presented on a computer screen, each being preceded by an identifying title. A neutral comprehension question (having a yes or no answer, but that did not resolve the ambiguous emotional meaning) followed each description. The order of story presentation was randomized. In the

subsequent recognition part, participants were presented with two disambiguating target sentences (one was a positive or non-error interpretation and the other was a negative or error interpretation) as well as two foil sentences implying either a positive or negative meaning but that did not represent a possible interpretation of the description. Participants were instructed to rate each sentence on how similar it was to the meaning of the original ambiguous description on a scale from 1 to 4 (1 = very different, 4 = very similar). The SRT has been widely used and known to be sensitive to detect interpretive bias in previous CBM studies (Lester et al., 2011; Mackintosh, Mathews, Yiend, Ridgeway, & Cook, 2006; Mathews & Mackintosh, 2000; Yiend, Lee, et al., 2014; Yiend, Mackintosh, & Mathews, 2005).

Filler task. An emotionally neutral paragraph with two comprehension questions was presented as a filler following training, designed to reduce any transient emotional differences induced during modification.

2.4 Procedure

Potential participants were sent the information sheet and BDI-II for screening purposes, and then given an appointment. On arrival, participants were given an information sheet and had the opportunity to ask questions about the study before giving written consent. Once the consent form had been completed, participants were randomly allocated to one of the four groups using an EXCEL program: SP, SN, EP and EN, and then completed baseline measures comprising: PANAS, LOT-R, VAS and SRT. They then completed the training program using the CBM-errors program according to assigned group (SP, NP, EP and EN). Immediately following training participants further VAS mood scales to assess the effect of training on state mood, followed by the filler task to equalize mood prior to cognitive testing.

A third VAS mood check was therefore completed after the filler to verify this, followed by the second version of the SRT. Finally, they were debriefed and thanked for their participation. The whole experiment took 1.5 to 2 hours and included additional measures to be reported elsewhere.

3. Results

3.1 Participant Characteristics

Randomisation to group resulted in the following number of participants in each: SP=20, SN=20, EP=20, EN=20. To check that no differences existed between groups prior to the experiment, an analysis of variance was conducted using Group (SP, SN, EP, EN) as the between subjects variable and participant characteristics as dependent variables. All four groups were comparable at baseline on all measures: age, $F(3, 78) = 1.02$, $p = .39$; trait positive affect, $F(3, 78) = 1.00$, $p = .40$, and trait negative affect, $F(3, 78) = .78$, $p = .51$; optimism (LOT-R), $F(3, 78) = 1.00$, $p = .41$; word fluency, $F(3, 78) = .63$, $p = .60$; depressive mood scores (BDI-II), $F(3, 78) = .38$, $p = .77$; and the pretest scores of the similarity rating task(target positive, target negative, foil positive and foil negative), all $F < 1.32$, all $p > .60$. There was no significant difference in gender, $\chi^2(3) = .16$, $p = .98$, across groups.

Since the main aim of this study was not to investigate a valence effect (positive vs. negative) but to detect a differential prospective imagery effect between the standard and the enhanced group, we directly tested this hypothesis by comparing the standard CBM-errors training with the enhanced CBM-errors training within each positive and negative training group. Therefore, separate analyses for positive training (SP vs. EP) and negative training (SN vs. EN), respectively were administrated on a series of dependent measures.

Outliers and the normality of the data was checked prior to analysis using skewness, kurtosis values and visual inspection of histograms and box plots.

3.2 Effect of training on state mood

Mean scores of happy and sad mood, respectively, were entered into a 2 (Group: SP vs. EP or SN vs. EN) x 2 (Time: baseline, immediately after training) repeated measures ANOVA, with group as the between subjects factor, and Time as the within-subjects factor. Table 1 presents means and standard deviations of happy and sad mood by group.

Happy. Within the comparison between the SP and EP groups, neither the main effect of Time or of Group, all *Fs* < 1, all *ps* > .87, nor the interaction effect of Time by Group, $F(1, 37) = 1.35$, $p = .25$, were significant. Within the comparison between the two negative training groups (SN vs. EN), the main effect of Time, $F(1, 37) = 24.64$, $p < .001$, $\eta_p^2 = .40$, was significant, with both groups becoming less happy (mean change of the SN: -1.44; mean change of the EN: -1.67). However, the main effect of Group and the interaction effect between Time and Group were not significant, all *Fs*< 1, all *ps* > .38.

Sad. Within the comparison between the SP and EP groups, no significant results were found for the main effects of Time or Group, or the interaction effect between Time and Group, all *Fs*< 1.30, all *ps* > .26. Within the comparison between the SN and EN groups, the main effect of Time was found to be significant, $F(1, 37) = 27.91$, $p < .001$, $\eta_p^2 = .43$, with both groups becoming more sad (mean change of the SN: +1.10; mean change of the EN: +1.71). The main effect of Group and the interaction effect of Time by Group were not significant, all *Fs*< 1.32, all *ps* > .26.

3.3 State mood after filler task

Independent sample *t* tests were conducted for mood scales completed after the filler task. As expected, there were no significant differences between positive training groups (SP vs. EP) on either happy, $t(38) < .47$, $p = .64$, or sad mood, $t(38) = .23$, $p = .82$. Within the comparison between negative training groups (SN vs. EN), no significant difference was found on happy, $t(37) = -.47$, $p = .64$, or sad mood, $t(38) = .47$, $p = .64$. Additional one-way ANOVAs also showed that there was no significant differences across the four groups (SP, SN, EP, EN) on either happy, $F(3, 78) = 2.12$, $p = .12$, or sad mood, $F(3, 78) = 1.59$, $p = .20$. This confirmed that any emotional differences between the training conditions that had been induced via the CBM-errors training were successfully dissipated by the filler task.

3.4 Effect of training on interpretation of previously unseen material

Similarity Rating test. A mixed design 2 x 2 x 2 x 2 ANOVA was administrated, with Group (SP vs. EP within positive training groups or SN vs. EN within negative training groups) as the between-subjects factor, and Time (baseline vs. test), Valence (positive vs. negative test items) and Sentence Type (target vs. foil), as the within-subjects factors. Mean similarity ratings for sentences was the dependent variable. Table 1 provides means and standard deviations of target non-errors, target errors, foil positive and foil negative sentences by group.

SP vs. EP. We found that the predicted four-way interaction effect of Group x Time x Sentence type x Valence was significant, $F(1, 38) = 5.67$, $p = .022$, $\eta_p^2 = .13$. This interaction was broken down between the time points (baseline vs. test). This reflected that there was a significant Group x Sentence type x Valence at test, $F(1, 38) = 4.96$, $p = .032$, $\eta_p^2 = .12$, but not at baseline, $F < 1$, $p = .99$. A significant Sentence type x Valence interaction was observed for both EP ($F(1, 19) = 52.78$, $p < .001$, $\eta_p^2 = .74$) and SP groups ($F(1, 19) = 27.26$, $p < .001$, $\eta_p^2 = .59$). We further examined whether there would be a significant difference between the

SP and EP groups in terms of each target/foil non-errors sentence (positive bias) and target/foil errors sentence (negative bias). This indicated that there was a significant difference between the SP and EP groups for target error sentence, $t(38) = 2.36$, $p = .024$, $d = 0.74$ ($M = 2.04$, $SD = .63$ vs. $M = 1.68$, $SD = .25$) (Figure2), but not for target non-errors sentence, foil errors sentence, and foil non-error sentence, $ts < 1.08$, $p > .29$ at test. This result was further confirmed by separate paired sample *t* tests of change over time within conditions. There was a significant decrease in target error sentences in EP group, $t(19) = 2.97$, $p = .008$, $d = 0.91$ (mean change = 0.30, SD = 0.45), but not in the SP group[3], $t(19) = .10$, $p = .92$. Finally, the change scores of target error sentence over time (T2 target error – TI target error) for each group were calculated in order to test whether the change in target error sentence between the SP and EP groups would be significant. There was a significant difference between the SP and EP groups, $t(38) = -2.15$, $p = .038$, $d = 0.68$ (mean change: 0.09 vs. 0.30). Finally, when checking a correlational analysis between the BDI scores at pretest and changes in negative bias as measured by the SRT, no significant relationship was found.

SN vs. EN. The expected four-way Group x Time x Sentence type x Valence interaction effect was not observed, $F < 1$, $p = .77$. There were some significant interactions, namely, Sentence type x Valence, $F(1, 38) = 15.09$, $p < .001$, $\eta p2 = .28$, and a non-significant trend of Time x Sentence type x Valence, $F(1, 38) = 3.34$, $p = .076$, $\eta p2 = .08$, and a Group x Sentence type x Valence, $F(1, 38) = 3.91$, $p = .055$, $\eta p2 = .09$. However, since none of these

[3] To address the question of whether the standard training produced the expected significant effects, we computed difference scores between (positive) non-error and (negative) error sentences and then tested whether these difference scores would yield a significant difference across the standard conditions (standard positive vs. standard negative). We found a significantly greater difference scores for positive than negative training conditions at post-test, $t(38) = 2.14$, $t<0.05$, but not at pre-test, $t<1$. This result indicates that there was indeed a significant training effect: the difference between non-error and error target sentences was greater following standard positive training than standard negative training (mean difference score = +1.80 for the standard positive and -0.31 for the standard negative).

could directly speak to our key hypotheses (which required either the significant four way interaction, or a significant Group x Valence x Time interaction) they were not further interpreted.

[Insert Table 1 about here]

[Insert Figure 2 about here]

3.6 Vividness across CBM-errors training

Participants were asked to rate the vividness of scenarios at the end of each block of CBM-errors training (every 7-8 items). One way ANOVAs were conducted to test whether there would be significant group differences in these ratings. A significant difference was found in both vividness, $F(3, 75) = 14.27$, $p < .001$, and positivity, $F(3, 75) = 10.39$, $p < .001$. Further contrast analyses revealed that the EP group rated the levels of vividness higher than the SP, $t(76) = -2.09$, $p = .04$; SN, $t(76) = -6.23$, $p < .001$, and EN groups, $t(76) = 4.09$, $p < .001$. The EN group also exhibited a significantly higher vividness than the SN group, $t(76) = -2.14$, $p = .036$. These results indicate that the enhanced groups, compared to the standard groups, used more vivid imagery during the training.

4. Discussion

Recent studies have drawn attention to the need for further investigation of ways to enhance the efficacy of CBM, if future clinical application is to be effective. As depression is characterized by a lack of prospective positive cognition, this is one obvious candidate mechanism which may improve CBM techniques aimed at depression. In the present study we therefore investigated whether including a component of prospective cognition with imagery would add to the efficacy of one particular CBM variant, CBM-errors. To test this hypothesis, CBM-errors with the addition of prospective cognition with imagery, was compared with the standard version of CBM-errors. We examined effects on state mood

(happy, sad) and interpretation of novel emotionally ambiguous information. The enhanced positive CBM procedure was more effective at decreasing negative interpretations than the standard procedure; therefore, hypothesis 2 was partly supported. This observed effect was not attributable to any mood effects that were carried over from the CBM training, as there were no significant mood differences following the filler task. The effect on state mood was not supported (hypothesis 1).

The current finding is broadly consistent with previous studies examining the role of imagery on interpretation biases (Hirsch, Clark, Williams, Morrison, & Mathews, 2005; Hirsch, Mathews, Clark, Williams, & Morrison, 2003). Hirsch and colleagues found that social phobia is associated with a failure to generate the normal positive interpretation bias that is observed in healthy controls, and suggested that the lack of positive interpretation might be because negative self-imagery or the negative content of imagery may block the creation of positive interpretations (Hirsch, Clark, & Mathews, 2006; Hirsch & Mathews, 2000). Indeed, there was evidence that holding the image of a successful interview appeared to be effective in blocking the generation of threatening interpretations of ambiguous social situations in socially anxious participants (Hirsch et al., 2005) whereas negative self-imagery was related to a lack of making benign inferences (Hirsch et al., 2003). Other studies have shown that induced positive and negative inferential bias (Hirsch, Mathews, & Clark, 2007) or access to positive or negative meanings of homographs (Hertel, Mathews, Peterson, & Kintner, 2003) influenced imagery. These results suggest that imagery and interpretive bias may reciprocally influence each other (Hirsch et al., 2006).

How did the enhanced CBM condition yield additional effects in decreasing negative interpretation bias, compared with the standard CBM condition? Under the same condition between the standard and enhanced groups, we additionally asked the participants in the enhanced group to imagine a future situation related to the event they previously read. As

such, those in the enhanced condition practiced thinking patterns of positive resolutions of future situations on top of current situations required in the standard condition. This might consolidate their believability of positive resolutions of "as-if" experience. In a similar vein, our results might be explained by the Reconstructive Memory Model (RMM) and Valuation Model (VM) (see Miloyan et al., 2014 for a review). According these two models, the repeated simulation of specific positive future events (RMM) might deflate risk attribution to future events and in turn, increase expectations for the occurrence of those events (VM). In our study, the enhanced CBM might have reduced the likelihood of an individual inflating the risk values associated with negative outcomes of ambiguous scenarios. This was further supported by previous studies showing that future time perspective affected the avoidance of negative information (Carstensen & Mikels, 2005; Demeyer & De Raedt, 2014).

On the other hand, in the previous study with a clinical population, Yiend, Lee, et al. (2014) also added a prospective cognition component during CBM-errors training, and found that the intervention group showed increased positive bias compared to the control group. However, the authors were unable to confirm whether the impact of CBM-errors training on positive bias was due to the additional prospective cognition component or CBM-errors training itself as they did not directly test the effect on future-directed cognition. The present study and Yiend, Lee, et al. (2014) used different instructions regarding prospective cognition; we provided explicit "future" word cues and promoted active self-generation using prospective imagery whereas Yiend, Lee, et al. (2014) provided predefined positive sentence stems for future-directed imagery related to previously read descriptions, along with picture images, followed by 5 seconds to allow for the generation of positive thoughts. Therefore, Yiend, Lee, et al. (2014) provided predetermined prospective imagery instead of self-generated prospective imagery. Future research is warranted to identify the most effective instructions for generating prospective cognition. One consideration is how the creation of

prospective imagery should be approached in different populations. For example, based on previous research evidence, depressed people are assumed to struggle with self-generation of prospective cognition.

In contrast to the above findings, there was no significant difference in positive interpretations between the enhanced and standard positive CBM training. There are several possible explanations for this. One possibility is that participants' may have attempted to decrease the discrepancy between their own experience of reality and the events described in the training materials. Thus, although participants in the enhanced positive CBM-errors group were encouraged to imagine more positive interpretations than the standard positive group, there might be a maximum positivity boundary that can be imposed on a healthy participant. An alternative possibility is that a single session is not enough to yield differential effect of positive interpretation between the SP and EP. Future studies including a dysphoric/depressed population with multi-sessions may provide a better test of any differential effect between the positive standard and positive enhanced CBM-errors procedures.

Finally, participants, regardless of training type (SN, EN), became less happy and more sad in the negative training conditions. This indicates a global effect of negative CBM training on state mood, regardless of additional ingredients. Interestingly this was not the case for the positive training conditions. Given the nature of a single session in the present study, future research should look at whether creating specific future expectations with more prolonged practice would yield a significant impact on mood.

This study had a number of limitations; however, it has also opened up a number of avenues for further research. First, the current study included a relatively small number of training trials. Previous studies with a single CBM-I session included around 100 passages (Mathews & Mackintosh, 2000), whereas our session included only 50 passages. Including baseline assessments prior to CBM manipulation is essential for adequate methodological

rigour, however this inevitably limits the time remaining in a single session for the training intervention itself. Another weakness may have been insufficient preliminary practice with participants concerning what was meant by future oriented thinking and how we can create it. Although some practice was given, this may not have been enough to encode a relatively complex concept. Exercises focussing on how to mentally project prospective events in mind could be helpful. We did not check emotional vulnerability to a stressor. We were, therefore, unable to detect how much our enhanced CBM training might protect the participants from mood deterioration in response to stress induction. Finally, we informed the participants of the aim of the experiment (to investigate the relationship between prospective cognition and mood), therefore we cannot rule out the expectancy or demand effects of CBM training although the participants were blinded that our study was a kind of therapeutic training. In future work investigating the role of prospective cognition in CBM interventions, it would be useful to include measures of hopelessness, as this construct is closely linked to the ability to generate positive thoughts about the future. Similarly more measures could be included to capture potential changes in positive cognitions and mood. For example, Including a more standardized mood measure (e.g., the PANAS) would increase confidence in the presence or absence of training effects on mood. Finally, as alluded to earlier, including individuals a wider range of positivity of prospective cognition would enable future studies to avoid any limitations imposed by possible ceiling effects.

Despite the limitations of the present study, this was the first investigation to look at the potentially enhancing effects of using prospective cognition as part of a CBM procedure, by examining effects on interpretive bias and state mood. The findings we present here should be taken as ‘proof of concept’ evidence that further investigation of prospective positive cognition is warranted, as a means to enhance those CBM techniques targeting

depression. Extending the current investigation to a sample dysphoria or depression could be an appropriate next step.

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Declaration of interest

The authors declare that they have no competing interests.

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Table 1.

Mean scores with standard deviations in parentheses in state mood and SRT by group

		Group	Baseline (T1)	Test (T2)	Mean change	After filler task (T3)
State mood						
Happy mood		SP	7.05(1.70)	6.86(2.04)	-0.19	7.32(1.98)
		SN	6.91(2.25)	5.47(1.76)	-1.44	5.99(2.15)
		EP	6.90(1.59)	7.06(1.64)	+0.16	7.04(1.80)
		EN	7.40(1.14)	5.73(1.95)	-1.67	6.29(1.97)
Sad mood		SP	1.60(2.37)	1.59(2.02)	-0.01	1.46(1.88)
		SN	1.81(2.47)	2.96(2.73)	+1.15	2.05(2.14)
		EP	1.17(1.46)	0.86(1.10)	-0.31	1.34(1.54)
		EN	1.01(0.94)	2.71(2.13)	+1.70	1.77(1.62)
		Group	Baseline(T1)	Test(T2)		Mean change
Similarity Rating Test (SRT)						
Target	Non-errors	SP	2.82(0.46)	2.95(0.40)		+0.13
		SN	2.91(0.49)	2.59(0.72)		-0.32
		EP	2.73(0.41)	2.80(0.46)		+0.07
		EN	2.88(0.45)	2.74(0.59)		-0.14
	Errors	SP	2.05(0.58)	2.04(0.63)		-0.01
		SN	2.06(0.53)	2.21(0.63)		+0.15
		EP	1.98(0.39)	1.68(0.25)		-0.30
		EN	1.98(0.35)	2.11(0.56)		+0.13
Foil	Positive	SP	1.85(0.61)	1.95(0.61)		+0.10
		SN	2.02(0.49)	1.84(0.70)		-0.18
		EP	1.80(0.54)	1.78(0.58)		-0.02
		EN	1.71(0.38)	1.75(0.47)		+0.04
	Negative	SP	1.48(0.33)	1.51(0.39)		+0.03
		SN	1.44(0.29)	1.49(0.40)		+0.05
		EP	1.45(0.40)	1.43(0.34)		-0.02
		EN	1.35(0.31)	1.48(0.46)		+0.13

Note. Happy and Sad mood: N of the EP and SN conditions = 19.

Figure 1. Example of Enhanced (left) and standard (right) Positive CBM-I training item

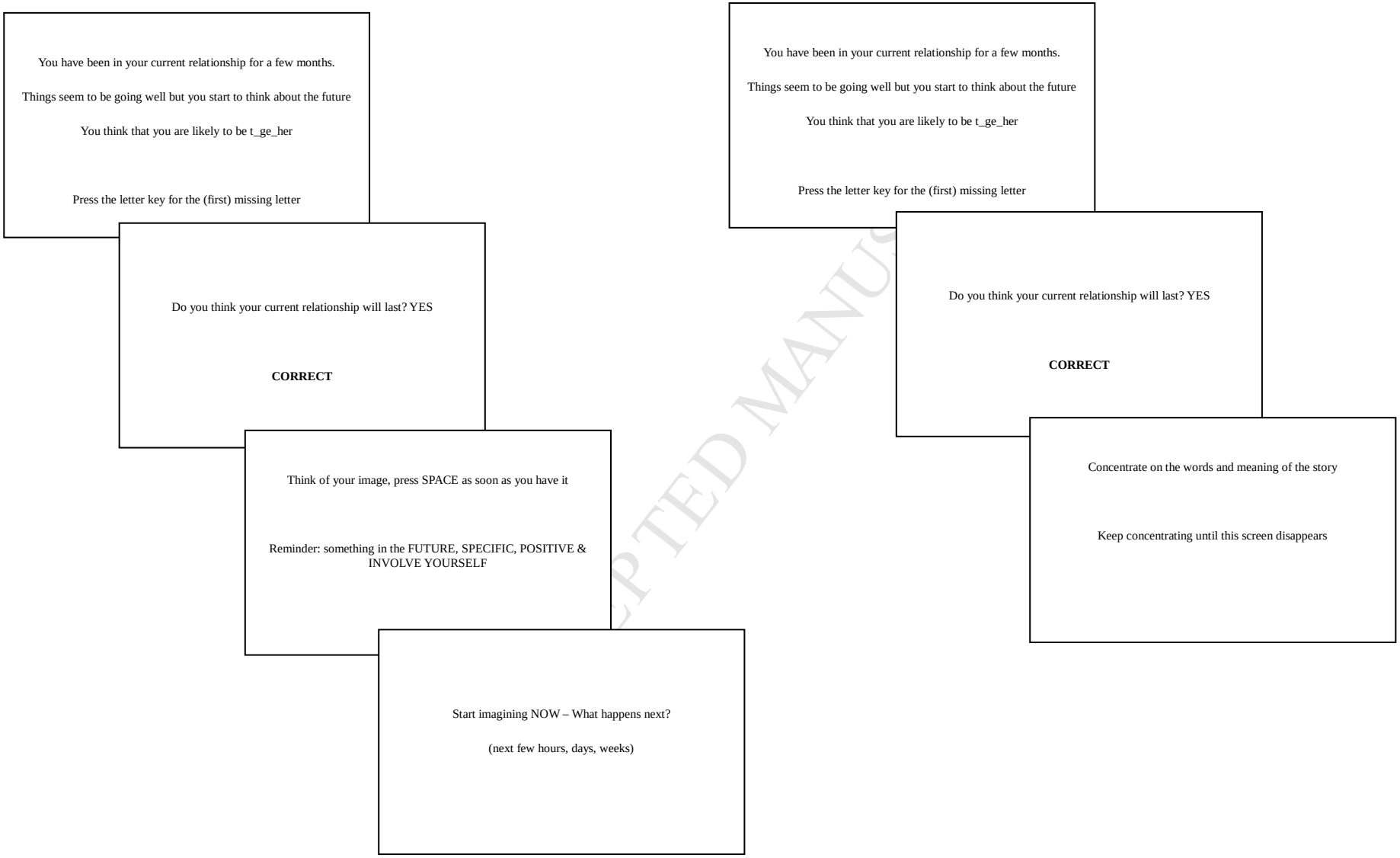
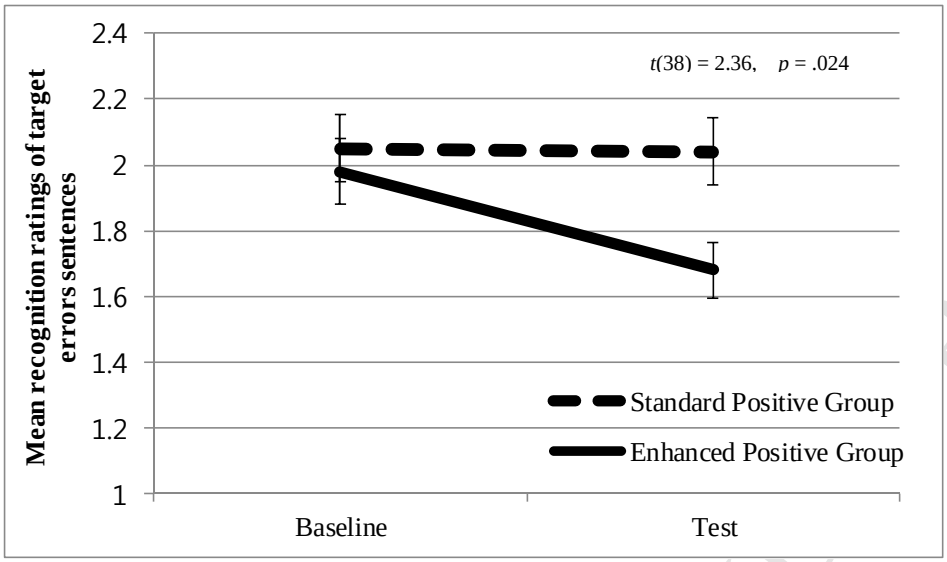


Figure 2. Mean scores from baseline to test for target errors sentences by group (Standard Positive, Enhanced Positive)



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Highlights for review

- A lack of positive prospective cognition is associated with depressive mood
- Inducing prospective positive cognition would have beneficial effect on mood
- Enhanced CBM-errors aims to promote prospective positive cognition
- Investigate differential effects between enhanced and standard CBM-errors
- Enhanced CBM-errors reduced negative interpretation bias